

BULLETIN OF THE RESEARCH COUNCIL OF ISRAEL

Section B ZOOLOGY

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OF THE RESEARCH COUNCIL
OF ISRAEL

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OCCURRENCE OF *MUGIL* IN THE RIVERS OF ISRAEL

LYKA BOGRAD

Sea Fisheries Research Station, Haifa

ABSTRACT

A study was made to find which of the six species of gray mullet present along the Mediterranean shore of Israel entered the streams and the extent of their distribution there.

Five species were found to enter the estuaries and move upstream at least as fry or small fish : *Mugil cephalus*, *M. ramada*, *M. saliens*, *M. labrosus* and *M. auratus*. These species were found to differ in the maximum size found in fresh water, and in their distribution along the streams. They were also found to differ in the season of migration as fry into the estuaries.

M. cephalus and *M. ramada* were the largest gray mullet to be found upstream, where they were present for most of the year. *M. saliens* was found to be most numerous in the estuaries. *M. labrosus* and *M. auratus* seem to prefer the sea, entering the streams only in the fry or fingerling stage.

From their distribution along the streams, the relative tolerance to fresh water of these species is indicated. *M. cephalus* and *M. ramada* are the most tolerant, *M. saliens* prefers brackish water and *M. labrosus* and *M. auratus* are the least tolerant. The tolerance as inferred here is in agreement with the results obtained in the various pond culture experiments.

M. ramada and *M. auratus* fry begin to appear in the estuaries in the latter half of January and continue to arrive for a period of two to three months. *M. labrosus* fry are seen for the first time in April. *M. saliens* fry are found in the estuaries in June while the fry of *M. cephalus* are taken regularly in the samples from August to January. The migration seasons of the various species of fry indicate that the spawning seasons of these species take place at different periods of the year.

The information obtained on the season of availability of *M. cephalus* fry in the streams has been useful to fish culturists who utilize this species in their freshwater ponds.

INTRODUCTION

A series of studies was begun in 1952 to provide some basic information on the family Mugilidae, the gray mullet, for pond culturists in Israel, who thought that this native fish would be suitable to raise in the freshwater ponds together with carp. Little was known at the time about the number of species present, their taxonomic characters or habits.

The presence of six species was established, and a key for the identification of the adults in the field was prepared (Bograd, 1955). This was followed by a key to the identification of the fry (Perlmutter, Bograd and Pruginin, 1957). Of the six species found along the Mediterranean coast, one, *Mugil labeo* (Cuvier and Valenciennes), is found only in the sea, no specimens having been taken in any of the streams studied. This species will therefore not be considered in this study. The other

five species : *Mugil cephalus* Linné, *M. ramada* Risso (Syn. *M. capito* Cuvier and Valenciennes), *M. saliens* Risso, *M. labrosus* Risso (Syn. *M. chelo* Cuvier and Valenciennes or *M. provensalis* Risso) and *M. auratus* Risso enter the estuaries and at least as fry ascend the streams to the furthest point sampled.

It had been established (Perlmutter et al., 1957) that *Mugil cephalus* was the most suitable species for pond-fish culture and the best time for obtaining fry for the ponds was in the month of December.

The identification of these five species of gray mullet is based on Berg's work (1949) which provides a practical means of separating *M. saliens* and *M. ramada* 60 mm or over, using external features. Soljan (1948) was also helpful since his work provided clear diagrams of the diagnostic features. Smaller fish were identified by examining the pyloric caeca which were found to have a characteristic number or arrangement for each of these species (Heldt, 1948) recognizable over all the sizes. The pattern of pigment spots on the lower jaw and jugular area was also used to identify the fry (Perlmutter et al., 1957).

The present study considers the variations in the distribution of the various species entering fresh water both along the length of the streams and with the seasons of the year.

HABITATS STUDIED, METHODS OF SAMPLING AND GEAR

The Na'aman, the Daliya, the Zarka, the Alexander and the Falik Rivers were chosen for study because they were unpolluted, had a steady flow of water all the year round and were close enough to the Sea Fisheries Research Station (located in Haifa) so that they could be reached for regular sampling (Figure 1). The Kishon and the Yarkon Rivers, although larger streams, were not used for regular sampling as they were highly polluted; however, occasional samples were obtained from commercial fishermen working in these estuaries.

In general, the permanent streams draining the Mediterranean coast of Israel are short, being between 10 and 20 kilometres in length. They arise from springs or swampy areas in the foothills which parallel the coastline, then meander across the narrow coastal plain to the sea. During the rainy season (in winter) the streams also receive the runoff from the hills, and the many dry wadis are filled with water flowing to the main stream. From April until November there is no rainfall, and the streams slowly decrease in size and become quite shallow across the beach area, so that by the end of summer it is possible to wade across the mouths. The mouths of the streams are sometimes closed by sand-bars after stormy weather, and the water, in forcing a new passage, may change the course of the river across the beach. If the current in summer is weak (as in the Alexander River) the water in the estuary may become strongly brackish. Although the water level drops during the dry season, a series of pools remain along the length of the streams, varying from three to six feet in depth. Here the bottom is usually covered with soft black ooze.

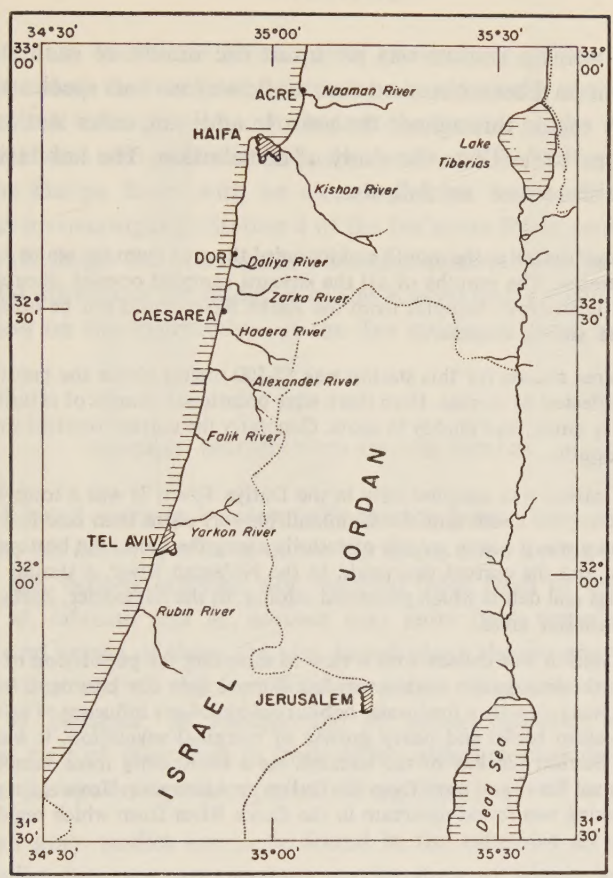


Figure 1

Streams which receive drainage from carp-ponds are well fertilized since both organic and inorganic fertilizers are regularly dumped into the ponds. This water, which becomes dark green from the numerous plankton organisms, seems to attract the mullet. It was observed that when carp ponds were emptied directly into the sea (at the end of a growing season) the temporary channel, thus formed, contained more mullet than the permanent stream nearby.

The temperature of the water in the streams varied throughout the year from 30°C in the summer to 20° in the late fall (November) and early spring (February). However, as no samples were taken during the heavy rains or when the weather was particularly bad, the lowest temperatures were not recorded. The lowest average temperature for the sea surface near shore was 16.1°C (Oren, 1952) and it is quite likely that the temperatures in the streams might reach at least that level.

Sampling stations

As a starting point a station was set up at the mouth of each stream wherever possible because it had been observed that mullets of various species and sizes moved in and out of this region throughout the year. In addition, other stations were located at points upstream to facilitate the study of distribution. The habitats in the various stations can be described as follows :

Station 1 — This was located at the mouth and included the area from the sea to a distance of about 20 metres upstream. The mouths of all the streams sampled opened through a sandy beach and were usually shallow. Samples from the Zarka River could not be obtained at this point because of the strong current.

Station 2 — The area chosen for this station was 50-100 metres above the mouth, where the river bed was little affected by storms. Here there were occasional clumps of cattails and the bottom, although mostly sandy, was muddy in spots. Generally the current was less strong in this region than at the mouth.

Station 3 — This station was sampled only in the Daliya River. It was a long deep pool, located at the junction of the beach and the mainland proper, more than one hundred metres from the mouth. There was a heavy growth of cattails along the bank, the bottom was covered with fine black mud and the current was weak. In the Na'aman River, a similar habitat was filled with sunken logs and debris which prevented seining. In the Alexander, Zarka and Falik Rivers there were no similar areas.

Station 4* — This station was chosen with a view to sampling the population of *Mugil* found well upstream from the sea. As this station was found more than one kilometre from the sea, it was likely that this was typically a freshwater habitat devoid of any influence of salt water. In general, because of the steep banks and heavy growth of marginal vegetation, it was difficult to take seine hauls at Station 4 in any of the streams. As a result only three samples were obtained from the Na'aman River and none from the Daliya or Alexander. However, a shallow open area suitable for seining was found upstream in the Zarka River from which regular samples could be taken.

Gear

Two seine nets were used, namely a cotton mosquito net with a mesh size of 4 mm stretched, and a nylon net with a hexagonal mesh of 8.7 mm major diameter. These nets were used either consecutively, or if enough people were available, concurrently. The mosquito net caught a high percentage of the tiny fish, but was selective, in that the fish of about 60 mm** or more in length were able to jump out of it. The nylon net with its larger mesh caught more of the larger fish (60 mm or longer) but allowed many of the smallest fry to escape. The largest sized fish caught by these nets were approximately 180 mm in total length.

* The chlorinities of this station near the end of the dry season (Aug. 1955, Aug. 1956) were 1.249 and 1.828.

** All lengths of fish refer to total length.

Miscellaneous samples

In order to obtain additional information, particularly on the fish whose size range was greater than that sampled by the experimental nets, several samples were taken from cast-net fishermen who worked at the source of the Na'aman River. Random samples were also obtained from the catches of fish culturists who worked upstream in the Daliya River with an electric-shocker and small-meshed lift-net.

A fyke-net set up overnight at Station 4 of the Na'aman River provided additional information on the larger fish at a regularly sampled station. Samples of fish obtained from commercial lift-nets in the estuaries of the Kishon and Yarkon Rivers provided some information on the distribution of the five species in large estuaries.

GENERAL DISTRIBUTION OF THE MULLET

The *Mugil* of Israel seem to be essentially marine fishes. They spawn in the sea, and one species, *M. labeo*, spends its entire life there, none having been taken from the streams in the various samples, nor reported from fresh or brackish water by the fishermen. *M. labrosus* and *M. auratus* may enter fresh water as fry or young fish, but as fry and young of these are also found along the sea-shore at these times it would appear that not all the fry of these species necessarily enter fresh water. Three species, *M. cephalus*, *M. ramada* and *M. saliens* however, seem capable of spending a great part of their lives in fresh water, although they descend to the sea at least prior to the spawning season, even during their years of immaturity.

Fry and small gray mullet are to be found in the estuaries all the year round. These small mullet however, are various species each of which is dominant at a different season of the year. As the fry of the various species arrive, they spread out along the length of the stream, so that at least some are found at the highest point sampled, but may go beyond that.

From the distribution of the five species of *Mugil* along the length of the streams and from the seasons of migration of the young into the estuaries, the relative tolerance of the species to fresh water and the presumptive spawning periods could be determined.

Distribution along the streams

Although the fry and small fish of a given species reached a peak in population all along the stream at approximately the same time, their numbers varied from the various points upstream.

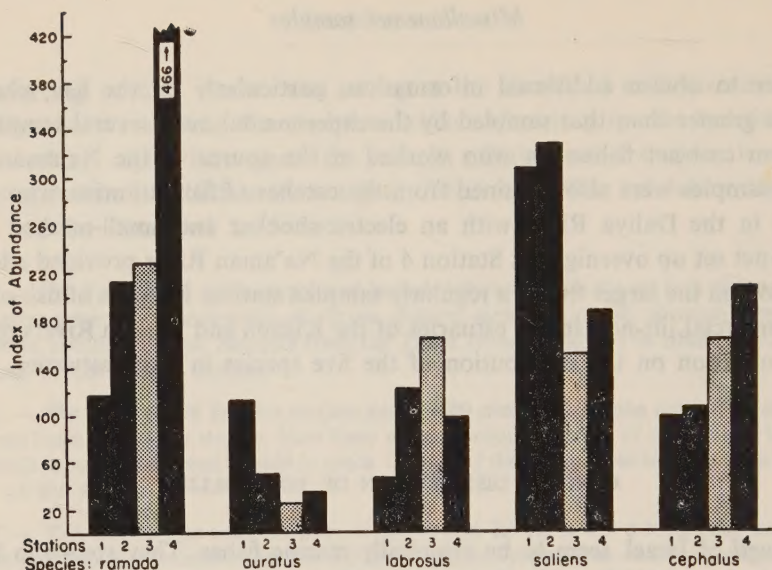


Figure 2. A Comparison of the distribution of *Mugil* species along the streams of Israel.

The index of abundance was obtained from the total of 12 monthly averages of number of fish taken per haul from each of the stations along the streams sampled.

The data for Station 3 was based on 7 months, weighed to a 12-month period.

The data on which this table is based was collected during the period November 1954-May 1957.

Total number of seine hauls: Station 1 — 124

Station 2 — 127

Station 3 — 17

Station 4 — 50

Total number of fish per station —

	1	2	3	4
<i>M. ramada</i>	824	2,239	31	1,941
<i>M. auratus</i>	1,170	529	66	174
<i>M. labrosus</i>	643	1,484	191	447
<i>M. saliens</i>	2,918	3,366	351	1,118
<i>M. cephalus</i>	968	818	377	704

Figure 2 has been prepared to illustrate the difference in upstream distribution of the various species. It should be noted that most of the distribution studies are based on the occurrence of individuals below 60 mm. It was observed during the seining operations that fish larger than 60 mm, particularly those over 100 mm often escaped the nets by jumping, so that their numbers could not be interpreted as representing the abundance of such fish. The mullets taken by regular sampling nets were therefore divided into two general size groups: those under 60 mm in total length and those over that size. Sixty millimetres was chosen arbitrarily, all the fish below this size were essentially young of the year. Few of these, if any, escaped the net by jumping so that the numbers caught could be considered fairly representative of the population.

In comparing the relative abundance of species from station to station along the streams, it should be noted that the data for Station 3 are based on that station in the Daliya River and on collections taken only during seven months of the year. It should be noted also that the data for Station 4 are based on samples taken from the Zarka River (covering eleven months of the year) and the Na'aman River (covering three months). Although no regular samples were taken from this station in the Daliya River, samples were obtained from the catches taken by fish-culturists in this region. The fish were taken by a fine-meshed lift-net and electric-fishing so that a wide range of sizes was obtained. The number and proportion of species and the size-range of the smaller fish taken here were very similar to those taken in the Zarka and Na'aman Rivers at the same date.

From the data available both from the regular samples taken (Figure 3) and the miscellaneous catches (Table I), the distribution of the larger fish along the streams seems to be similar to that of the fish 60 mm or less. However, as pointed out previously, the observations are not conclusive and only their presence or absence at the various stations could be noted (Table II).

From Figure 2 it can be seen that *M. ramada* below 60 mm are distributed all along the length of the streams, and are found in the largest numbers at Station 4, the upstream station. Large fish up to 300 mm were taken by miscellaneous catches and commercial nettings all along the streams, but it was not possible to judge their relative abundance at the various stations. The smaller-sized *M. auratus* may be found all along the length of the streams, but the numbers are highest at the mouth, decreasing to Station 4, where they are numerous only during the migration season of the fry. Specimens of *M. auratus* taken upstream were 70 mm or less and in the estuaries regularly sampled, the largest specimen found was 160 mm. Even in the estuaries of the larger streams such as the Kishon and the Yarkon Rivers, commercial sized *M. auratus* 300 mm or more are rarely taken inside the mouth but are common in the sea just outside.

M. labrosus under 60 mm increase in numbers from the mouth to Station 2 (and to Station 3 in the Daliya R.) but decrease again to Station 4. Larger fish up to 60 mm are to be found all along the streams, but not in large numbers. Commercial sized fish (300-450 mm) are to be found in the estuaries only, and although they occur frequently there, *M. labrosus* of that size are more common along the seashore.

Both *M. auratus* and *M. labrosus* occur in fewer numbers in the streams than the other three species which enter fresh water.

M. saliens occur in greatest numbers at Stations 1 and 2 but are common all along the length of the streams decreasing in numbers towards the fourth station. All sizes of this species are found in the lower parts of the streams all the year round,

TABLE I
Mugil species caught by miscellaneous gear in the streams of Israel

River	Area	Gear	<i>Mugil</i>	No.	Size-range	Date
Na'aman	source	throw-net	<i>ramada</i>	60	128-259	II. 55
"	"	"	<i>cephalus</i>	8	145-342	"
"	"	"	<i>saliens</i>	7	120-179	"
Na'aman	Station 4	fyke-net	<i>ramada</i>	132	40-204	VI. 55
"	"	"	<i>saliens</i>	15	70-99	"
Daliya	Station 4	electric-shocker	<i>ramada</i>	18	75-139	I. 56
"	"	"	<i>cephalus</i>	7	30-79	"
"	"	"	<i>saliens</i>	29	45-74	"
"	"	"	<i>labrosus</i>	6	85-134	"
Daliya	Station 4	electric-shocker and lift-net	<i>ramada</i>	25	74-240	II. 56
"	"	"	<i>cephalus</i>	84	25-324	"
Alexander	Station 2	throw-net	<i>ramada</i>	4	171-226	III. 55
"	"	"	<i>labrosus</i>	1	137	"
Kishon	estuary	lift-net	<i>ramada</i>	247	100-194	IV. 57
"	"	"	<i>cephalus</i>	9	65-485	"
"	"	"	<i>labrosus</i>	44	85-139	"
Kishon	estuary	lift-net	<i>ramada</i>	10	220-230	VIII. 56
"	"	"	<i>cephalus</i>	26	205-439	"

TABLE II
Presence of Mugil species over 60 mm. T.L. in the five streams sampled for each month (regular samples)

Species	I	II	III	IV	V	VI	VII	VIII	XI	X	XI	X
Station I												
<i>cephalus</i>					X	X		X	X	X		X
<i>ramada</i>					X	X						
<i>saliens</i>	X		X	X	X	X	X	X	X	X	X	
<i>labrosus</i>			X	X	X			X	X	X	X	
<i>auratus</i>	X			X	X	X	X	X				
Station 2												
<i>cephalus</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>ramada</i>	X	X	X			X	X	X	X			
<i>saliens</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>labrosus</i>			X	X	X			X	X	X	X	
<i>auratus</i>				X	X	X	X	X				
Station 3 not shown as the data was obtained only from the Daliya												
Station 4												
<i>cephalus</i>	X	X	X	X			X	X				
<i>ramada</i>	X	X		X	X	X	X	X	X			
<i>saliens</i>	X	X	X			X	X	X				
<i>labrosus</i>	X		X	X	X		X	X				
<i>auratus</i>							X					

but upstream this species becomes rare or is absent during the months of April and May just before the fry appear. In general this species is smaller than the other four species entering fresh water. In the estuaries *M. saliens* may reach as much as 400 mm although the majority are about 200 mm in length or less. Upstream the largest observed (taken by cast-net) was 180 mm.

From Figure 2 it can be seen that specimens of *M. cephalus* below 60 mm are distributed all along the length of the stream increasing in numbers towards Station 4. Commercial sized specimens up to 450 mm of this species have been taken all along the streams from the mouth to Station 4, and in the Na'aman River even at the source. From their distribution along the length of the streams the five species of *Mugil* can be divided into three groups. The first group includes two species which can be found all along the length of the streams, from fry up to commercial length (250 mm in total length or more) in greater or lesser numbers all the year round: *Mugil cephalus* and *M. ramada*.

Mugil saliens is present in the lower parts of the streams all the year round, upstream it is found as fry or small fish not exceeding 180 mm in total length. These are present upstream in large numbers only during the late summer and early fall. This species is also common along the sea-shore, but is not taken in large numbers by the commercial fishermen. It seems to be most common in the estuaries.

The third group consists of *M. labrosus* and *M. auratus* which ascend the stream as fry or small fish but remain there for a short period only (one to three months) and are rare or absent in the streams as fish of commercial size. *M. labrosus* of commercial size is taken occasionally in the estuaries particularly of the larger streams, but *M. auratus* of a similar size is rare or absent. Both these species are common along the sea-shore.

There is a similarity in the distribution of these five species along the length of the streams in Israel with that in the brackish water lakes in Egypt and in the lagoons of Tunisia. The distribution indicates that the species differ in their relative tolerance to fresh water. There seems to be a correlation between the tolerance thus indicated and the growth and survival of these species in freshwater ponds as observed in Israel (Perlmutter et al., 1957).

In Egypt, Wimpenny (1930) observing the mullet population in Lake Menzaleh (Nile delta) noted that *M. auratus* was found mostly in the channel between the lake and the sea, but seemed to prefer the sea coast. *M. cephalus* and *M. ramada* were found all over the lake, but *M. saliens* seemed to "flourish in more saline water" than *M. cephalus*, *M. ramada* or *M. labrosus*. However, he went on to remark that the latter did not occur in sufficient numbers "to draw any inference as to its distribution". It seems therefore evident that this conclusion regarding the latter species should not be given much weight and that in all probability *M. labrosus* occurs predominately in the sea off the coast of Egypt as it does off the coast of Israel. Lake Menzaleh receives both fresh water from the Nile and sea water from the Mediterranean Sea, the general distribution of the five species of *Mugil* in relation

to the salinity of the water in this lake seems to be similar to that found in the streams of Israel, and the lagoons of Tunisia (Heldt 1948).

In Israel a series of rough experiments were carried out by pond culturists to study the effects of transferring young fish of the five species to freshwater ponds (Perlman et al., 1957). *M. cephalus* had the highest survival and growth rate of the five species and was found most suitable for pond culture. *M. ramada* had a high growth rate but its survival rate was third highest. *M. saliens* had a low growth rate but survived well, second only to *M. cephalus*. The survival rates of *M. labrosus* and *M. auratus* were the lowest. The growth rates of these two species were better than that of *M. saliens* but as the maximum sizes attained by *M. labrosus* and *M. auratus* are greater than that of *M. saliens* this may not be of any significance.

Wimpenny (1932) carried out the contrasting experiment in a saltwater pond (40 ‰). Approximately 1,500 mullet fry, mainly *M. cephalus* were introduced into the pond, some in the spring of 1929, and the rest in December. Of the fish obtained the following autumn, only 39% by weight were *M. cephalus* and these were in an emaciated condition. *M. auratus* "a species rarely found" was the next important species by weight. The specimens of *M. auratus* were in good condition as were those of *M. saliens* which were also found. *M. ramada* which had been introduced with the others died within a few days of their introduction.

From the various observations on their distribution it may be concluded that of the five species of *Mugil* entering fresh water *M. cephalus* and *M. ramada* are the most tolerant to fresh water; *M. saliens* prefers brackish water and although *M. labrosus* may tolerate fresh water in the fry or young stages, the larger fish prefer brackish or sea-water. *M. auratus* is least tolerant to fresh water.

SEASONAL OCCURRENCE OF THE SPECIES AND THEIR PRESUMPTIVE SPAWNING PERIODS

Although the *Mugilidae* are of circumglobal distribution in the temperate and tropic zones, and of some importance commercially wherever they are found, there is little information available on the actual area, time of spawning or early development of any of the numerous species (Sarojini, 1957; Broadhead, 1953). It has been generally assumed that spawning takes place in the sea somewhere offshore and this has been observed for at least several species off the coast of Florida: *M. cephalus* (Arnold and Thompson, 1958; Anderson, 1958), *M. curema* (Anderson, 1957) and *Agonostomus monticola* (Anderson, 1957). In the Mediterranean area Sanzo (1930) described the early development of artificially fertilized eggs of *M. cephalus* and some of the embryonic and post-embryonic stages of *Mugil* species found in the sea (1936). Heldt (1948) described the spawning of the five species of *Mugil* found in Tunisia (these are the same as those found in Israel) as indicated by the months during which ripe fish were found in the lagoons of that region.

As no ripe fish of any of the species were found in the present investigation, except

few individuals of *M. ramada*, the spawning periods of these species were estimated from the time of the first appearance of the fry of the different species.

It was found that at any one station, for any one species, the pattern formed by the change in numbers of fish per haul is essentially the same for the five rivers sampled, hence the data for all the rivers are discussed together. Station 2 was found to have the widest range of species present, all five being present for at least part of the year. Larger fish if present, were ordinarily taken here rather than at the mouth which is usually shallower and more exposed. The collections at this station were therefore chosen to show the fluctuations in populations throughout the year. These data are illustrated in Figures 3a, 3b and 3c. In these figures it will be noted, as mentioned previously, that fish larger than 60 mm are poorly represented. Thus again the discussion will deal almost exclusively with the young of the year.

Figures 3 a,b and c show both the numbers of *Mugil* species present during any particular month of the year and their size ranges as well as the changes in numbers of the different size groups for any one species from month to month. For example, in Figure 3a during the month of January, there are four species to be found: *M. saliens*, *M. cephalus*, *M. ramada* and *M. auratus*. From Figure 3b, it can also be seen that the four species present vary in size range and numbers taken. *M. saliens* are the general are the larger fish and form the major portion of the gray mullet population. *M. cephalus* is the second most numerous species, but most of these fish are smaller than *M. saliens*. *Mugil ramada* and *M. auratus* form only a small portion of the samples taken in January and consist almost entirely of small fry, although a few specimens of *M. ramada* over 100 mm may be taken as well. These last two species mentioned begin to appear in the samples only in the latter half of the month. On the other hand the changes in numbers and size range of a single species can be followed from month to month by looking at each panel in succession. Thus in January, *M. auratus* occurs in numbers varying from about 22-32 mm. In February, the population size of this species has increased, and the size range varies from about 18 to 40 mm. By March this species seems to have reached a peak in numbers, varying from about 28-48 mm in length. Similarly, the variations in populations during the year can be followed for the other species.

The seasonal variations for each of the species are discussed below.

Mugil ramada

The fry of *M. ramada* arrive early in the calendar year, about the middle of January. Few were taken in the experimental seine hauls along the sea-shore (Table II), but they were observed in the sea near the estuaries moving towards the mouth at that time of the year. The smallest specimen of *M. ramada* found was 10.4 mm but the majority of the fry taken at the end of January, when they first appear in the seine hauls varied from 14-15 mm. If the range of 10-15 mm can be considered as that of recently arrived fry, then from Figure 3 (a and b) it is evident that the season for the migration of the small *M. ramada* fry from the sea into the mouths of the streams begins in January, reaches a peak in February decreases again in March and definitely ends by the end of April or the beginning of May. This season lasts altogether about 3 to 3 1/2 months.

The changes in numbers of this size group shows up well in the individual catches. For example, on 17.II.56 the catch taken at the mouth of the Na'aman

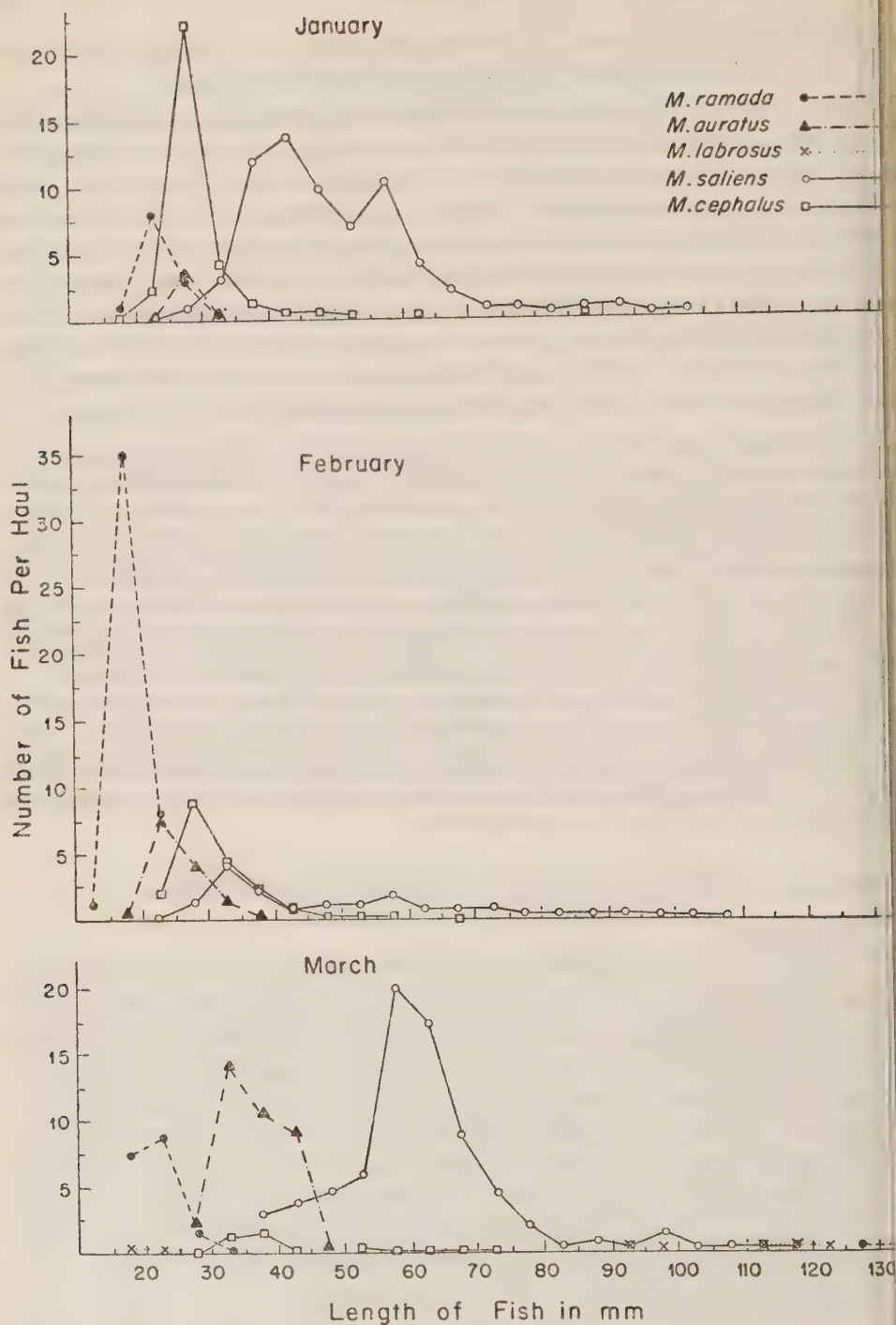


Figure 3a

Size composition of fish taken each month based on the average number of fish per haul taken at station 2 of all streams:

(XI. 1954—V. 1957)

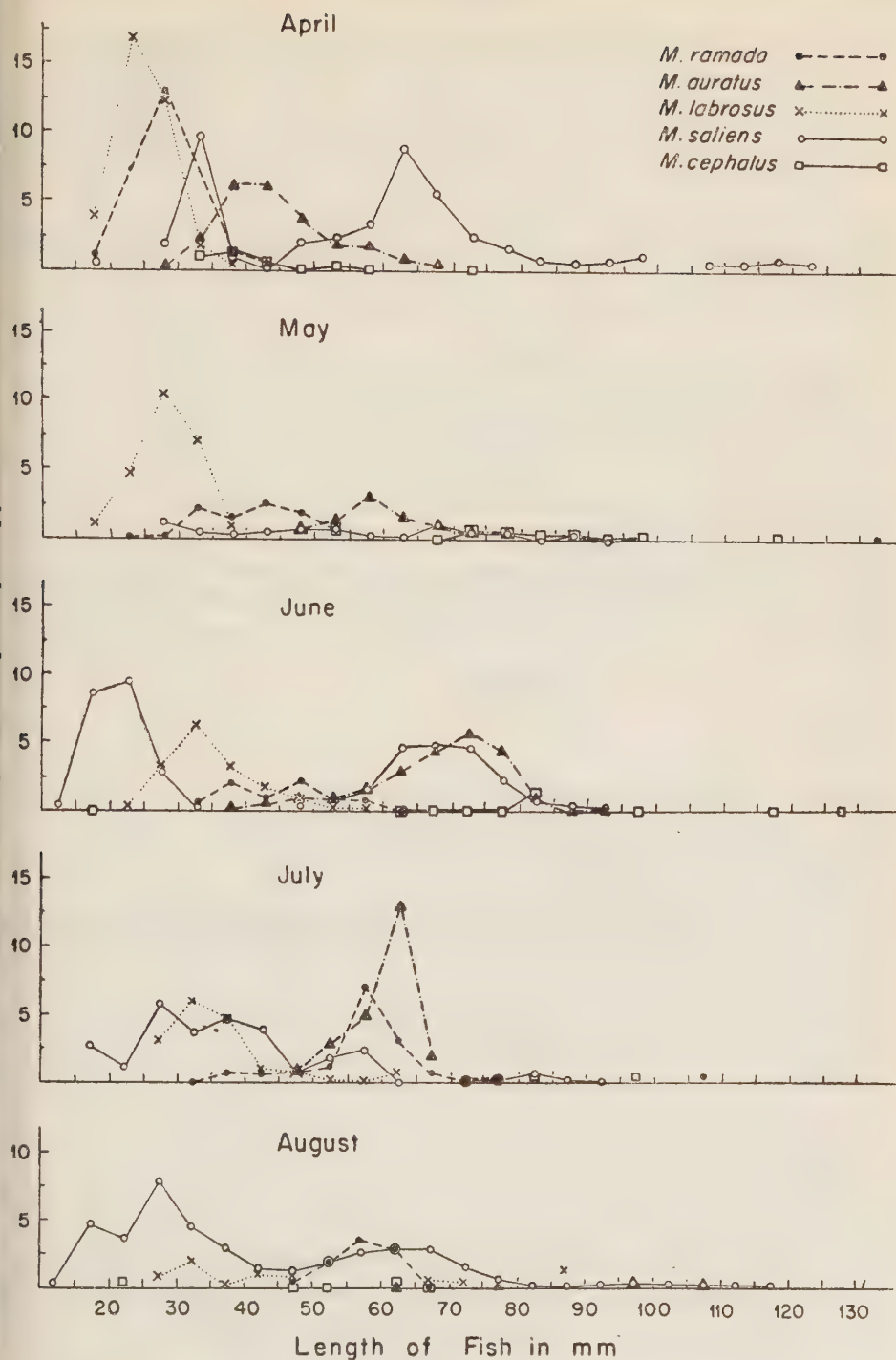


Figure 3b

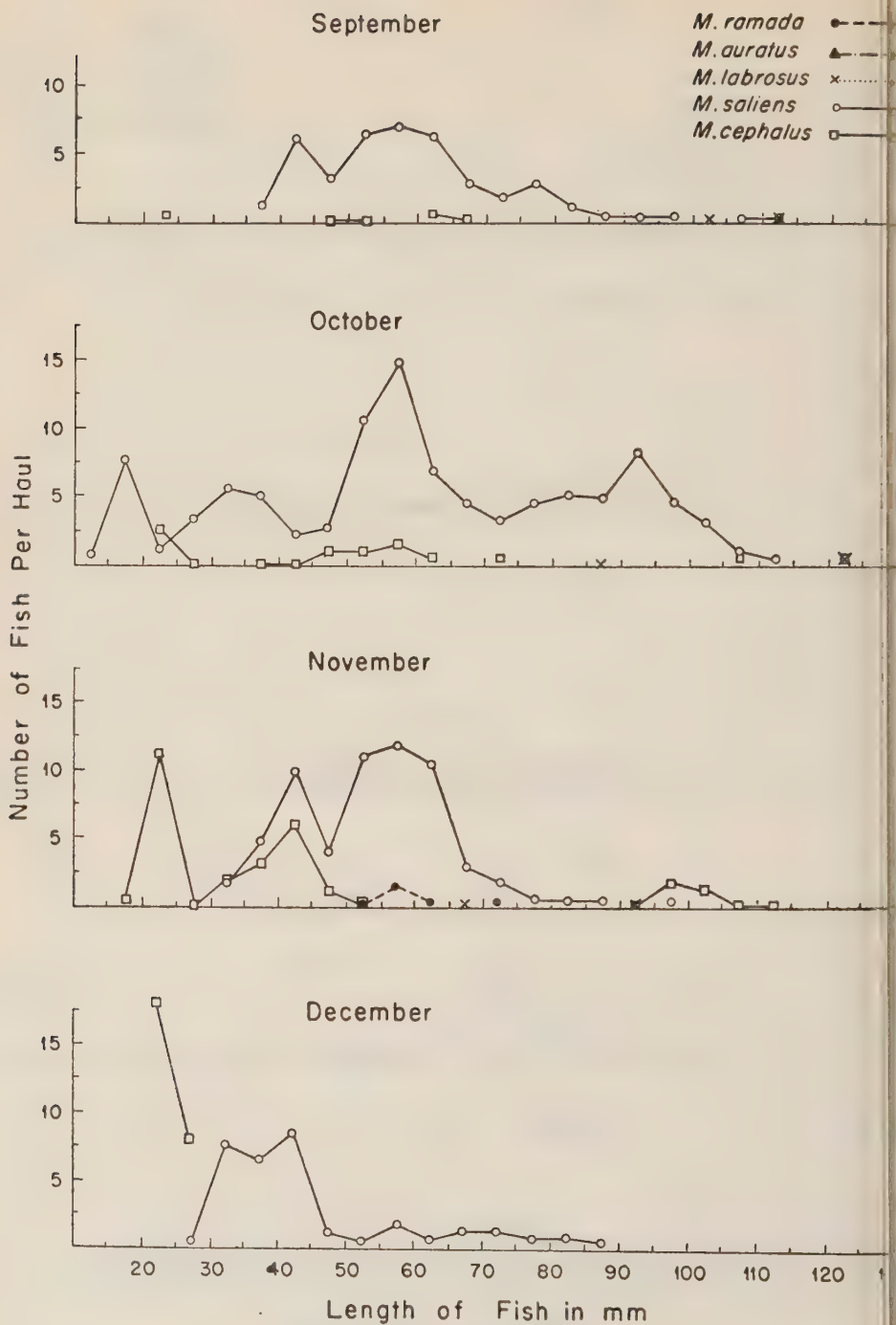


Figure 3c

River contained 87% *M. ramada* (77 per haul) varying from 15-24 mm. A seine haul taken in III.56, at the same station, consisted of 48 % (34 per haul) *M. ramada* which varied from 20-29 mm. Even the smallest of these was larger than those caught earlier in the season indicating that no more of the very young fry were entering the streams.

Similarly in the Daliya River mouth, on 24.I.55 *M. ramada* (15-24 mm) formed only 1 % of the catch, but by 28.I.55 these fry formed almost 50 % of the sample taken in the same area. By 4.IV.55, there was only one specimen of this species in the 15-24 mm size group, indicating again the arrival of the very young fry.

M. ramada of the size groups taken by the regular sampling (150-180 mm approx.) disappear from the streams from September until January, or if present are rare. In January when the young fry appear in the samples they form a distinct group varying from 15 to 34 mm, noticeably different from the larger sized fish of the same species, which also appear in the samples about the same time suggesting that fish one year or more return to fresh water. In the catches taken by the electric-shocker upstream in the Daliya in January, a similar size-group of larger *M. ramada* were taken, varying from 75-139 mm. In February, specimens taken in this same area (Table V) by the electric-shocker and lift-net varied from 74-240 mm.

Mugil auratus

The fry of *M. auratus* were the largest of the five species entering the estuaries. The smallest of this species observed was 19 mm in total length (the second largest species of fry were those of *M. labrosus* which ranged from 17-19 mm). Most of the fry of *M. auratus* ranged from 20-29 mm at the time when they first appeared in the samples. Taking this size-range as indicating recent arrival from the sea, then from Figure 3 it can be seen that the migration of the smallest *M. auratus* into the estuaries lasts from January until April. Large numbers of these fry are also found at this time along the sea-shore, in rock pools or along the beach (Table III) often at some distance from any freshwater flow, suggesting that perhaps not all the *M. auratus* fry enter fresh water.

The fry first appear in the estuaries towards the end of January and their numbers in the regular samples increase and reach a peak in March (Figure 3a and b). A sample, taken 24.I.55 from the mouth of the Daliya River, contained no *M. auratus* but by 28.I.55 three specimens varying from 25-29 mm were taken in one haul, forming 2.5 % of the catch. On 28.II.55 at the station, 22 *M. auratus* fry were taken per haul, forming 54 % of the catch. These fry varied from 25-40 mm in length. In the sample taken on 4.IV.55, the young of *M. auratus* formed 98 % of the catch (146 specimens of this species per haul) but these ranged from 30-50 mm in length indicating the end of the migration season

TABLE III
Size range of *Mugil* species caught along the Mediterranean shore by experimental seine nets
(Total length given in mm)

Month	I	II	III	IV	V	VI	VII	VIII	IX *	X	XI	XII *
<i>cephalus</i>	20-29 69	0	14-40	0	0	0	0	20-24 130-179		0	20-24	
<i>ramada</i>	0	15-24	14-29	145-164	0	0	0	90-154		100-129	0	
<i>saliens</i>	25-149	25-44	55-59 50-114	85-94	0	15-19 70-89	15-19 14-24	30-34 40-84		45-94	0	
<i>labrosus</i>	50-69	90-144	20-24 90-94	15-29 155-159	0	20-29 25-29	20-74 25-49	30-74 45-64		0	0	
<i>auratus</i>	20-34 20-34	18-39	25-49 25-49	155-164 25-39	15-34 20-29 30-44 49	25-29 30-84	35-54 45-59 55-59	119-129 55-164 70-99 75-99		0	0	

* No samples were taken in Sept. or Dec.

for the smallest fry. A similar pattern was found in the other streams. This season lasts 2 1/2 to 3 months.

Mugil labrosus

Using the same criterion as before for defining the season of migration of the fry, it can be seen from Figure 3 a and b that for *M. labrosus* this lasts from March until June. Fry of this species are also numerous along the sea-shore at this time, particularly in the rock pools (Table III). *M. labrosus* varying from 22-29 mm were caught in the rock pools near Caesarea 12.V.51 and 12.V.52*. On 11.IV.54, 124 specimens of *M. labrosus*, 17-29 mm in length were found in this same area. By V.54, the specimens caught there were 17-34 mm. By September of the same year a sample taken from the rock pools consisted of 19 *M. labrosus* 100-174 mm in length together with 12 specimens of *M. auratus*. The smallest fry were 17-19 mm and most of those observed in the estuaries for the first time were of this size.

The fry spread out along the length of the stream and are found at the highest station sampled. *M. labrosus* is found in large numbers all along the length of the streams during the migration season of the fry, then the numbers slowly decrease but the species is regularly found in the samples until August. During September, October and November, a few individuals may be taken in the streams but these are uncommon. From November until the following March, this species is not found in the streams.

As is the case with the other species except *M. auratus*, when the migration of *M. labrosus* from the sea to the stream begins, not only do the young fry appear, but also larger fish. At the second station of the Na'aman River, samples taken 2,4.III.55, contained specimens of *M. labrosus* ranging from 80-144 mm in length but no fry. Samples taken here on 24.III.55 contained two specimens (17-34 mm) per haul, indicating that the migration of the young had begun. Eleven specimens of this species, less than 19 mm in length were taken per haul on 18.IV.55, and 8.V.55, this number decreased to two fish, less than 19 mm per haul. The migration period for the smallest fry lasts about 2 1/2 months. It is during April and May that this species is most numerous in the streams.

Mugil saliens

The majority of *M. saliens* fry vary from 13-15 mm in length when they first appear in June, although some are as small as 12 mm. Fry of 14 mm length are still found in October so that the migration period for the young fry (12-15 mm in length in this case) lasts 4 1/2 to 5 months. This is longer than that of *M. ramada*, *M. auratus* or *M. labrosus*. During this period (June to October)

* From the collections of the Hebrew University of Jerusalem.

TABLE IV
Season of appearance in streams of smallest specimens of the five *Mugil* species

+ = period present

○ = presumptive spawning period

Species	Size-range of smallest fry (mm)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Stations 1 and 2													
<i>ramada</i>	10-15	⊕	⊕	+	+	+						○	○
<i>auratus</i>	19-20	○	⊕	+	+								○
<i>labrosus</i>	17-19		○	○	⊕	+	+						
<i>saliens</i>	12-15				○	○	⊕	⊕	+	+	+		
<i>cephalus</i>	15-20	+					⊕	○	⊕	⊕	⊕	+	+
Station 4 (Na'aman and Zarka Rivers only)													
<i>ramada</i>	10-15	+	+										
<i>auratus</i>	19-29				+								
<i>labrosus</i>	17-19					+							
<i>saliens</i>	12-15							+	+	+	+	*	+
<i>cephalus</i>	15-20	+						+	+	+	+	○	+

* No samples were taken at Station 4 during November.

few small specimens of *M. saliens* were found in the experimental hauls taken along the sea-shore indicating that most of these fry enter fresh water.

In a sample taken 8.V.55 from Station 2 of the Na'aman River, only one specimen of *M. saliens* (48 mm) was found in a catch of 416 mullet. By 25.V.55 at this same station 21 *M. saliens* (40-50 mm) were found in a sample of 371 *Mugil*. In the sample taken on 10.VI.55 at this station, there were 490 mullet, 231 of which were *M. saliens* of two size groups. The smaller sized fish varied from 12-29 mm and the larger ones from 55-89 mm in length. By 13.VII.55 the major portion of the sample taken consisted of *M. saliens* (321 out of 335 *Mugil*). The smaller fish still formed a discrete group.

Mugil cephalus

M. cephalus fry are the last to arrive during the calendar year, their migration period lasting from the end of June to the beginning of December. The smallest fish observed was 15 mm in total length, but most of the fry when they first appear in the catch vary from 18-24 mm. *Mugil cephalus* of small size were rare along the sea-shore during the period when they were observed in the estuaries.

Although very few specimens of small *M. cephalus* fry were found in the Na'aman River estuary in June (one specimen of 20 mm was taken 10.VI.55, and 17 specimens 25-39 mm were taken 31.VI.55), no specimens of this size range were found in any of the other estuaries at this time, nor were any taken in July. Small *M. cephalus* fry do not appear regularly in the samples until

August. At this time too, larger specimens, 60 mm or over, also appear in larger numbers. In the Daliya River, a sample taken from the second station on 21.VI.55 contained only six *M. cephalus* in one haul forming 7 % of the catch. These specimens varied in length from 80-99 mm. On 30.VIII.55 a sample taken at this same station contained 9 fry varying from 20-39 mm in length, these forming only 6 % of the catch, but by 10.XI.55, *M. cephalus* fry (20-49 mm) formed 99 % of the catch. Considering the size range of 15-20 mm as that of the youngest fry, then it can be seen (Figure 3a, b, c) that the period of migration of these fry into the streams lasts at least six months, or if June can be considered as the beginning of the migratory period, it is even longer.

The number of small fry found in the samples reach a peak about the end of November, then the number of fry of the 18-24 mm group decreases slowly, a few small specimens being found as late as the beginning of January.

M. cephalus is found all along the length of the streams at all sizes from fry to commercial-sized fish of 450 mm or even more. This species is the largest taken in fresh water, where it is found all the year, becoming scarce only in May and June. During the winter months this species and *M. saliens* were most numerous downstream.

From monthly samples taken in the streams it was seen that the fry of each of the five species of *Mugil* appear in the estuaries at a definite season (the seasons are summarized in Table IV), increase in numbers and for a time become the dominant form numerically; then either return to the sea, as in the case of *M. auratus* (which is not found over 60 mm upstream) or grow to a size not usually taken by the regular sampling seines. The migratory period of the fry of one species is followed by that of another indicating that the spawning period of each of the five species is during a different season of the year. The spawning seasons may overlap slightly as there are young mullet to be found in the estuaries all the year round. As each species remains for a different length of time in fresh water the number of species present in the estuaries at any one time varies. In April and May all five species may be found in the streams (Figure 3) while in November and December or the beginning of January, only two species, *M. cephalus* and *M. saliens* may be present.

PRESUMPTIVE SPAWNING PERIODS

It is presumed that the spawning periods of each of the species takes place a month or more before the entrance of the first of the smallest sized fry of the species concerned (see Table IV).

In Israel the only ripe specimens found were *M. ramada*. Both males and females were found, all appeared to be in the stage just previous to spawning. All the specimens observed were from catches made by commercial fishermen, and although these were observed over a period of several years, they were all found during the month of December. Most of the ripe specimens were taken either at the mouths or just in the estuaries of the Yarkon, the Hadera and the Alexander Rivers, but a number

were also taken upstream in the Kishon River (1960*). However, as this last-mentioned stream is highly polluted above the estuary, the polluted area may have acted as a barrier to discourage the fish from moving to the sea.

As the smallest fry of *M. ramada* do not appear in the estuaries until the middle of January there is an approximate lapse of about one month or more between the time of spawning and the arrival of the fry to the shore and fresh water. In discussing the spawning period of *M. cephalus* as based on larval collections at sea, Anderson (1958) also suggests the possible period of 3 to 4 weeks between the time of spawning and the time the larvae reach a length of about 20 mm total length. Heldt (1948) describes the spawning period of *M. ramada* in Tunisia as lasting from early October to the end of November, but this is based on the capture of ripe fish only.

The fry of *M. auratus* begin to appear by the end of January (Table IV) suggesting that the spawning period of this species begins about the same time or soon after that of *M. ramada*. The smallest sized fry of *M. auratus* are found in the samples taken in the lower parts of the stream for a period of 2 1/2 to 3 months. In Tunisia this species is described as spawning from the beginning of September to the end of October, that is the spawning season of this species there appears to begin earlier than that of *M. ramada*.

Mugil labrosus fry are not found in the streams until April. These then appear regularly in the samples for a period of three months, their numbers reaching a peak in May. The spawning period of this species appears to take place after that of *M. ramada* and *M. auratus*, perhaps in February or March, and is also of some months duration. The spawning period of this species in Tunisia is described as taking place from December to the end of January. In Israel this may occur later and continue for a longer time, as the period during which the small fry appear lasts about three months.

The period during which the small fry of *M. saliens* are found regularly in the streams lasts about five months, beginning early in June. This suggests that the spawning period extends over a longer period of time and occurs later than the foregoing species. Heldt (1948) describes the spawning of this species as taking place from mid-June to the beginning of August.

In Israel a few fry of *M. cephalus* were found as early as June, but as none were taken during July, this may have been the result of unusually early spawning. Fry began to appear regularly in the samples in August and were found until the beginning of January, a period of at least five months.

Arnold and Thompson (1958) were the first to observe the spawning activities of *M. cephalus* and to collect both the ripe fish and fertilized eggs as well as the small fry from the same area. They observed *M. cephalus* spawning in December, 40-50 miles southeast of the Mississippi River delta. Anderson (1958) from his study of

* Personal communication from Miss Bruria Abraham, The Hebrew University.

the collections of *M. cephalus* larvae taken at sea, describes the spawning season of this species along the Atlantic coast of the United States of America (from lower Florida to North Carolina) as occurring from October to February "but is largely confined to the period of November to January, with the peak in December".

Paget (1923) reported that in Egypt the fry of *M. cephalus* arrive from the middle of August to the end of December, coinciding closely with that observed for this species in Israel and Florida. In Australia (Thomson, 1951) *M. cephalus* with ripe or spent gonads have been found from May to September (the winter months) in the sea, the spawning period lasting approximately five months. Heldt (1948) reported that he observed ripe *M. cephalus* from mid-August to the end of September in Tunisia (from his report the various spawning periods of all five species lasts two months or less). In Corsica, *M. cephalus* is described as becoming ripe during the period of August to September (Belloc, 1938).

A practical outcome of the field work of this investigation was that the fish culturists have learned to take advantage of the season of migration of the fry (of the species found desirable for pond culture) to make their collections of young fish. As mentioned previously *M. cephalus* and *M. ramada* were found to be most tolerant to fresh water and to grow to a large size there. The fish culturists go out to fish for *M. cephalus* at the end of November and continue until mid-January. At this time nearly all the fish under 60 to 70 mm are *M. cephalus* so that by using a small-meshed net, and discarding the larger fish, an almost pure culture of *M. cephalus* can be obtained. Fishing is continued until the middle of January when large numbers of *M. ramada* fry arrive. As this species does not reach as large a size as *M. cephalus* (but grows well) fishing is stopped when *M. ramada* forms approximately 50 % of the catch of fry.

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LETTER TO THE EDITOR

addendum à la liste des espèces méditerranéennes d'Ascidies d'Israël^{1,2}

Cystodytes dellechiaiei (Della Valle)

Atlit, 12.IX.49 (un cormus brun très altéré, à spicules d'aspect "ferrugineux"). G. Haas.

Atlit — Tantura, 12 et 13.IX.49. G. Haas.

Bat-Yam, 5.X.49. G. Haas.

Metrocarpa nigrum (Herdman)

Tantura, 13.IX.49. G. Haas.

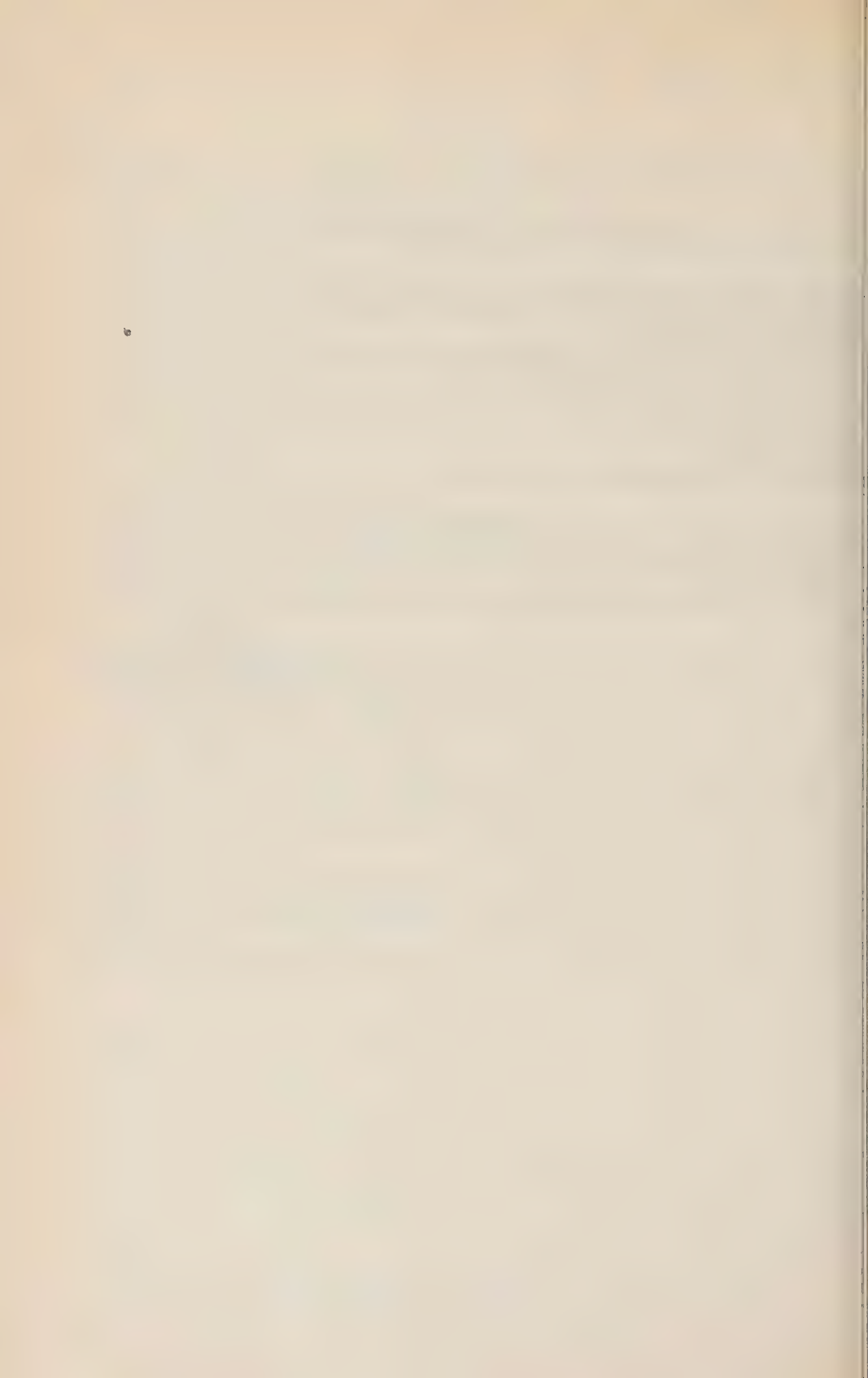
Ialocynthia papillosa (L.)

(Localité et date inconnues).

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J. M. PERES
Station Marine d'Endoume
Faculté des Sciences de Marseille.



**PROCEEDINGS OF THE MEETING
OF THE ZOOLOGICAL SOCIETY OF ISRAEL**

HELD ON JUNE 12, 1960 IN JERUSALEM

SECOND SERIES, FIRST MEETING



PROCEEDINGS OF THE MEETING OF THE ZOOLOGICAL SOCIETY

Some problems of evolution applied to protozoology

ADLER, *Department of Parasitology, The Hebrew University of Jerusalem*

The main problems of evolution are implicit in the whole realm of living organisms. Some problems lend themselves to experimental investigations as in the case of protozoa because the time scale is contracted and a relatively large number of generations can be observed in a short time.

Darwin considered that under natural conditions variation and speciation are very slow processes. In the case of some parasitic protozoa e.g. *Trypanosomas* and *Leishmania* species variation, i.e. change in properties, is a relatively quick process under laboratory conditions and is obviously more rapid than under natural conditions. After long continued passage by syringe in laboratory animals, pathogenic African trypanosomes differ from wild strains. *Leishmania tropica* ceases to be infective for mice and hamsters after continued culture for 18 months or so on artificial media. *Trypanosoma lewisi* ceases to be infective for rats after prolonged culture. In the case of the Trypanosomidae variation is slower under natural conditions than in the laboratory and biological constancy is maintained by passage through intermediate hosts. *Histomonas meleagridis*, which is highly pathogenic for turkeys, loses its pathogenicity after prolonged culture.

Change in antigenic constitution is the first stage in speciation and some species maintain a number of races antigenically distinct though morphologically indistinguishable e.g. in the genera *Paramecium*, *Leishmania*, etc. Recently Hanna Kotlerkin in the Department of Parasitology has shown that *Trichomonas vaginalis* maintains at least 8, and *Trichomonas hominis* at least 2 antigenically distinct strains. With improvement in methods of maintaining bacteria-free cultures of protozoa this phenomenon — i.e. the presence of antigenically distinct strains within recognized species — will no doubt be shown to be widespread.

The problem of mutation can also be conveniently studied experimentally in protozoa; the production of strains resistant to specific chemical groupings is in most cases probably an artificial selection of mutants involving the exclusion of non-resistant individuals which originally constituted the overwhelming majority of the population.

The problem of the rate of production of species is important in the case of protozoa. Haldemidht has suggested that species may be formed rapidly but this may be doubted in the case of higher animals in which variations accumulate slowly. In

protozoa change in antigenic composition probably precedes changes in morphology. There are probably instances of rapid formation of new species in the case of Ciliata where closely related species differ in the number of nuclei. Any change in the number of nuclei must be a rapid process because intermediate transitional stages are impossible. Calkins' observation on *Uroleptus mobilis* is important. He noted an instance of conjugation in which the two conjugants did not separate but fused; the resulting organism divided and its progeny observed for more than a year consisted of individuals with a double set of nuclei. This process can explain the appearance of multinucleated species in the Ciliata and is of special evolutionary significance in the view of Thadze's theory of the origin of Metazoa from Ciliata. Thadze considered that the earliest Metazoa were not *Coelenterata* as is usually supposed but *Turbellaria* represented by their most primitive group, the ciliated Acoela, which were derived from multinucleate Ciliata which became multicellular.

Host adaptation and pathogenicity is another subject which can be studied experimentally. It is generally considered that tolerance for a parasite is the result of long adaptation and selection in the host and the parasite, while pathogenicity indicates a failure in adaptation possibly due to relatively recent contact between the host and parasite.

In this connection it is interesting to mention the experiments of Linder in the Department of Parasitology of the Hebrew University of Jerusalem. Linder found that *Leptomonas culicidarum* and *Herpetomonas muscoidarum* invariably produced a fatal infection in fourth stage larvae of local *Galleria mellonella* after inoculation into the haematocele; these flagellates are perfectly harmless for their natural hosts. On the other hand *Leishmania adleri* usually produces a mild infection when introduced into the haematocele of *Galleria mellonella*. Two strains of *Trypanosoma cruzi* failed to infect the local strain of *G. mellonella* after inoculation into the haematocele although Hoare infected *G. mellonella* in England and found all stages of *T. cruzi* in the haematocela. The negative results with local *G. mellonella* are probably due to strain differences in the *G. mellonella* or *T. cruzi*. We thus see all stages, non-infectivity, mild infectivity and fatal infectivity in the case of parasitic protozoa introduced into a new host with which they have no ecological contact under natural conditions.

Some remarks on the fauna of Ubeidije, near Afikim (Jordan Valley)

G. HAAS, *Department of Zoology, The Hebrew University of Jerusalem*

The earliest quaternary fauna known from the Palestinian area was excavated at Bate¹ at Bethlehem and more fully described by Hooijer⁴ who stressed its purely Villafranchian character.

Another faunal assemblage was excavated by M. Stekelis in 1936-37 at Gesher Banot Jaacov (Jordan Valley). According to Hooijer⁴, this fauna, which was accompanied by a very early lithic culture, belongs to the Mindel-Riss interpluvial.

To the remains mentioned by Hooijer³ (kept at the Department of Zoology of the

Hebrew University of Jerusalem) we add (from the same site):

lemmys caspica (?)

Equid teeth: An upper molar¹, small, with asinoid characters; 4 upper molars without caballine fold, most probably of zebroid horses.

Bovid teeth: ca. 20 molars. The lower M_3 (6 spec.) are of 3 size groups:

Crown length \times width

Smallest:	31 \times 13 mm	(? <i>Leptobos</i> sp.)
Medium:	37 \times 14 mm	(? <i>Bison priscus</i>)
	38.5 \times 14 mm	
Largest:	48 \times 16 mm	(? <i>Bos primigenius</i>)

A metapodium of a ruminant of the proportions of *Gazella*.

A rugose lower molar, 2/3 the size of *Dama mesopotamica*, with a clear external stylus between the pair of dental prisms — most probably *Capreolus*.

A frontal base, and a basal fragment, of antlers — ? *Dama*.

A frontal base of an antler — ? *Capreolus*.

The Carmel Cave Fauna (Bate⁴, from level F of Tabun to level B of Mughareh-Wad) belongs to the Riss-Wurm interpluvial up to later parts of the Quaternary. Neuville's excavation at Oumm Qatafa⁵ (E. of Bethlehem) is most probably somewhat older than level F of Tabun.

The fauna discovered at Ubeidiye (near Afikim) seems, on account of the pebble culture accompanying it, to be older than the Gesher Banath Jaacov fauna. The stratigraphical conditions point in the same direction. The following forms could be identified in a provisional manner:

Uarias, mostly pectoral spines and

cranial elements

cyprinoid, large

nuran (1 spec. only)

estudo cf. *graeca*

lemmys cf. *caspica*

myd turtle, large

trionyx sp.

gama cf. *stellio*

aranus sp. (Not *griseus*, much bigger)

nhinga sp.

haradriiform bird, big, perhaps *Vanellus*

Aquila sp.

ringillid

other birds' bones, still to be identified

? *Hyaena* sp.

? Mustelid, small

Felis cf. *lynx*

Spalax sp.

Hystrix sp.

Microtinae

Gerbillinae

Proboscideans

Rhinocertid

Equidae, asinoid

Equidae, zebroid

Sus cf. *scrofa*

Sus sp.

Hippopotamus

Cervid, large

Erinaceus sp.

Canid, size of *C. lupus*

Canid, similar to *C. aureus*

Canid, size of *vulpes*

Dama cf. *mesopotamica*

Very large antelope

Gazella sp.

Bovidae, small

The prevalent species are: *Clarias*, *Clemmys*, *Trionyx*, horses and *Hippopotamus*.

Of special interest are the occurrence of the freshwater turtle *Trionyx* in the Jordan system (where it is absent today); the large Varanid (total length 1.5–2 m); and the presence of rhinoceros and Proboscidean remains.

The find of a human incisor, and of two small fragments of a very thick hominid skull, is of special importance.

All the specimens have been excavated in an area of ca. 150 m². There is no doubt that a resumption of this work will uncover rich material and enhance our knowledge of the fauna and climate of this area during the early Quaternary.

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Remarks on the evolution of Geckos (Reptilia: Gekkonoidea)

Y. L. WERNER, *Department of Zoology, The Hebrew University of Jerusalem.*

Underwood had suggested a detailed evolutionary scheme for the geckos, according to which the procoelous geckos were considered as primitive¹. He later accepted the more generally held view that these evolved from amphicoelous geckos². Both Underwood's classification¹ and his later suggestion² are adopted here, but a more detailed hypothesis is outlined in the hope of showing what research is now needed if the evolution of geckos is to be elucidated.

The most primitive living geckos are the amphicoelous Diplodactylinae of New Zealand: they have a spectacle, a simple vertical pupil¹ (evolved within the group), a most primitive skeleton³, and narrow or little-broadened toes⁴. However, they are ovoviviparous. While this may well be a local adaptation, and the hard egg-shell may be primitive, the assumption that geckos were originally live-bearing might explain both the peculiar shell and the almost uniformly low number of eggs. Oviparous Diplodactylinae, which became quite widespread¹, gave rise to all other geckos:

The procoelous, spectacled, Sphaerodactylidae evolved in Central America from Diplodactylinae which retained a round pupil¹.

The procoelous Eublepharidae evolved from Diplodactylinae which had developed narrow pupil, either retained, or else regressed to, narrow toes, and apparently eye-developed eyelids. They too gained a broad distribution¹.

The amphicoelous Gekkoninae developed from broad-toed Diplodactylinae with narrow pupil. They evolved diverse forms of toes, including regression to narrow toes, and also some lines reverting to round pupils. They gained a world-wide distribution and were perhaps responsible for the geographical retreat of Diplodactylinae and Eublepharidae¹.

Comparative embryological studies of vertebrae, toes and, especially, eyelids and spectacle, should contribute valuable facts to this discussion. The hypothesis might also be supported by cytotaxonomic data. It has already been shown^{5,6} that Gekkoninae and Eublepharidae have less chromosomes than most other Sauria⁵. Diplodactylinae may well prove to have a karyotype closer to that of Sauria in general⁶. Pygopodidae, probably related to Gekkonoidea⁷, have not yet been studied in this respect.

I wish to thank Prof. G. Haas for his advice, and Prof. G. Underwood for his stimulating correspondence.

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The biology of *B. pavo* Risso (Pisces Blenniidae)

LEV FISCHELSON, *Tel Aviv University*

Blennius pavo Risso, found chiefly on the northern rocky shore of Israel, was bred successfully in captivity.

Detailed observations of courting and breeding habits were made at a water temperature of 25°C and pH 7.4.

During the mating season the fish manifest sexual dimorphism accompanied by a vivid colouration of the male. Several females may be attracted by one male, and follow him to his territory. After the eggs have been laid and fertilized the male drives away the females, and takes over the care of the developing eggs. The eggs hatch after 10 days, the mortality rate of the young being very high. Twenty seven days after hatching, their behaviour resembles very closely that of young fish in nature.

Developmental change in the web spinning instinct of *Uloborus*¹

RASZA SZLEP, *Department of Zoology, The Hebrew University of Jerusalem*

Uloborus begins web-weaving at an earlier developmental stage than other orb-weavers. Till the first moult, *Uloborus* spins a primary-type web, which is a modification of an orb-web. At the final spinning stage, the pre- and post-moult spinning activities differ in that movements of the pre-moult spider are radial instead of spiral. This results in lack of a viscid spiral and appearance of additional radii in addition to the ordinary ones. The temporary spiral is preserved in a completely pre-moult web.

The post-moult web has a normal orb-web structure.

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Biological observations on the Forest Doormouse *Dryomys nitedula* Pallas, in Israel (Rodentia, Muscardinidae)

E. NEVO AND E. AMIR, *Oranim*

The Forest doormouse is found in central and western Upper Galilee in the Maquis formation of the *Quercus calliprinos* — *Pistacia palaestina* association. In 1959-60 a project was started combining field survey and laboratory observation.

The doormouse is active the whole year round, in contrast to its behaviour in Europe, where the animal hibernates in tree-crevices and holes during the winter. While activity is mainly nocturnal, sporadic day activity was observed in nature and in captivity. The doormouse is omnivorous, its diet consists of seeds, fruit and insects, as is seen in the remains left in its feeding places located in deserted nests of *Turdus merula* and *Streptopelia turtur*.

In 350 hours of field survey only 35 animals were seen. A hundred doormouse nests were located, which served as sleeping and breeding places. The nests, resembling those of birds, are found in groups of 4-6 on adjacent trees at a height of 1 to 6 m. The different groups of nests can be as much as 100 m apart. The nests are spherical to elongated in shape, with an opening at the top or at the side. They are built of twigs of the same tree in which they are located, while their inner lining is made of leaves of Graminae and pieces of bark. As *Quercus* predominates in this association, about 80% of the nests were found on this tree. Most of the nests were found deserted, only one or two in each group were populated: 25 out of the 100 located.

Parturition takes place 2-3 times a year, in spring, March-April, midsummer, July, and in autumn, September-October. There are three young of 1.3 g in each litter².

Laboratory observations show that in Israel the doormouse passes only short dormant periods. In a 20-hour "hibernation" the rectal body temperature was found to be close to the temperature outdoors (12.5°C and 11.5°C rectal body temperatures at 12 and 10°C outdoor temperatures respectively). During this period respiration was irregular with intervals of 1-5 minutes between groups of 4-10 deep respiratory movements (cf. 3). On awakening, the doormouse returns to a homeo-thermic state with rectal temperature of 33°C.

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Parturition in scorpions

A. SHULOV, *Department of Zoology, The Hebrew University of Jerusalem*

Observations were made on parturition in three species of the Buthidae family and in *Nebo hierochonticus* (Diplocentridae). *Nebo hierochonticus* is truly viviparous, the young being born free; whereas in the Buthidae, they are enveloped by embryonic membranes which are discarded shortly after birth ¹.

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The burrows of scorpions

P. AMITAI, *Department of Zoology, The Hebrew University of Jerusalem*

Field observations were made on the form and construction of burrows of scorpions in Israel. The Buthidae occasionally dig only small burrows, the entrance to which they may block with soil when flooded. *Scorpio maurus fuscus*, *S. maurus palmatus* (Scorpionidae) and *Nebo hierochonticus* (Diplocentridae) generally live inside burrows, characteristic to each species and even subspecies.

Representatives of the order: Amblypygi (class: Arachnida) found in Israel

R. ROSIN, *Department of Zoology, The Hebrew University of Jerusalem*

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The effects of the venom of the spider *Loxoscelis rufescens* (Sicariidae) on white mice

H. PENER-SOLOMON, *Department of Zoology, The Hebrew University of Jerusalem*

Direct stings of *Loxoscelis rufescens* proved to be toxic and often lethal to white mice. The effect of the venom is primarily neurotoxic, contrary to the well-known necrotic effect of *L. laete* and *L. reclosus* from the U.S.A. The venom is relatively strong compared to that of *Latrodectus XIII guttatus* — "Black widow" (Theridiidae).

The biology of *Calliptamus palaestinensis* Bdmr. with special reference to the development of its eggs

M. P. PENER AND A. SHULOV, *Department of Zoology, The Hebrew University of Jerusalem*

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**PROCEEDINGS OF THE MEETING
OF THE
ZOOLOGICAL SOCIETY OF ISRAEL**

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PROCEEDINGS OF THE MEETING OF THE ZOOLOGICAL SOCIETY

Outlines to the Paleolithic avifauna in Palestine

E. TCHERNOV, *Department of Zoology, The Hebrew University of Jerusalem*

Investigations of caves in various areas of Palestine, particularly on Mount Carmel, have yielded numerous fragments of avifaunistic material from the Middle and Upper Pleistocene.

Reports have hitherto been published concerning Pleistocene birds from two sites: 1. from the Middle Paleolithic beds of El-Zuttiyeh cave, Wadi Amud, Upper Galilee, excavated in 1925-6 and described by D. M. A. Bate (Bate, 1927). 2. 25 species of birds were determined by Prof. G. Haas from the Upper Mesolithic (Natufian) beds of Abu-Usba cave, Mount-Carmel (Haas, 1952).

I was accorded the opportunity of investigating the avifaunal material from two further sites: 3. Oumm-Qatafa cave, near Hebron, excavated by R. Neuville in 1928, 1932 and 1949. The excavations at this site represent Lower Paleolithic beds with three cultural stages, Tayacian, Acheulian and Micoquian. 4. Kebara cave, Mount Carmel, excavated over a long range of years by Prof. M. Stekelis. Kebara cave contains a rich fauna of various animal classes, from the Middle and Upper Levalloiso-Mousterian beds. The material from these two beds is interesting and significant in that it is derived from both sides of the Bate "faunal break" (Bate 1939); between the Middle and Upper Levalloiso-Mousterian, or, according to Bate's hypothesis, between prevailing conditions of a humid, tropical climate in the Upper Acheulian, through a semi-arid transitional period, to a cold, nearly boreal, climate in the Upper Levalloiso-Mousterian.

The Middle and Upper Paleolithic beds of Kebara are, more or less, continuous with the older Lower Paleolithic Oumm-Qatafa beds, and can yield a fair picture of the faunistic evolution during the entire period covered.

Our systematic survey covers nearly 50 species of birds from Oumm-Qatafa and about 70 species from Kebara. Some of these are extinct species which have vanished in the Post-Paleolithic period. By far the most conspicuous fossil specimen is a huge pheasant, considerably larger than any living species known today, which was first described by Bate (1927) from El-Zuttiyeh as *Phasianus hermonis*, and found by us again in Kebara. Another fossil from Kebara is a lark, which again is larger than any known recent species, *Melanocorypha* sp. (Tchernov, in prep.). Yet another interesting bird is a Passer, found at Oumm-Qatafa which is closely related to *P. domesticus*, but seems to have possessed a maxilla constructed along more primitive lines (also in prep.).

Other remains appear to be closely related to the recent fauna of tropical Africa; an *Onychognathus* sp. not found in our recent fauna; a large kingfisher, *Megaceryle* found today in Central Africa; a large African swallow, *Hirundo* cf. *senegalensis*,

and a huge *Otis*, which reminds us of the large recent bustards from Arabia and Africa.

Birds which show affinities to the recent Central and Eastern Asiatic fauna are: large *Oriolus* from Kebara cave, which is much larger than the recent circum-mediterranean species *O. oriolus*, and a very small starling which was determined both from Oumm-Qatafa and from Kebara caves, as pertaining to either of the East Asiatic genera *Sturnia* or *Temenuchus*. One other, probably a Central Asiatic bird, determined both from Oumm-Qatafa and from Kebara, is a small pigeon of which the metacarpi seem to indicate a forest dwelling bird.

Two other interesting species from the Kebara deposits—Middle Levallais-Mousterian—conforming to Bate's transitional semi-arid climate conditions are typically palearctic birds; *Pica pica* and *Pyrrhocorax graculus*, which probably retreated northwards as late as historical times.

It seems justified to assume that the tropical, African elements, which contributed a fairly consistent part to the composition of our fauna, as well as to the entire Levantinian faunal assemblage, were in continuous retreat during the Plio-Pleistocene period. Only those African species which found adequate ecological niches, enabling them to endure a mediterranean climate, could emerge into the historical and recent periods. The eurasiatic elements, on the other hand, which increased in number during the Plio-Pleistocene, are at present the main component of the Levantinian fauna. Although birds are extremely vagile, they have undergone exactly the same faunistic evolution as the major animal groups. We find, for instance, side by side in the Paleolithic beds, a Central Asiatic *Ellobius*, African *Hippopotamus* and *Phacochoerus*, together with *Ursus arctos*. To the same extent we find, without being unduly surprised, on the one hand a *Megaceryle*, *Sturnia* and *Temenuchus*, and on the other *Pica pica* and *Pyrrhocorax graculus*, jointly in the same faunal assemblage.

We should be reminded of the continuation of these conditions obtaining in our country at the present time such as *Troglodites* (wren), and *Ketupa* (the Indian fish-owl) breeding at the same locality, or such surprising juxtapositions of reptiles like *Ophisaurus* and *Lacerta* with *Echis*.

Contrary to what should have been expected from Bate's hypothesis, the avifauna of Kebara cave do not show any significant alteration during the transition from the Middle to the Upper Levallais-Mousterian beds. The same types of birds, more or less, continue to survive on both sides of Bate's "faunal break". It appears that the glacial fluctuations had but little effect on the faunal inventory of the Levantine areas, and it seems that during the Pleistocene such climatic changes as occurred, were confined within broadly-mediterranean limits.

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Notes on the status of some birds in Israel

H. HOVEL, *El Gasali St. Haifa*

1. The Desert Bullfinch (*Rhodopechys obsoleta* Lichtenstein)

This interesting Bullfinch seems to have occurred rather irregularly in the past. Several authors^{1,2,3} described it in the past decades from Palestine, chiefly as a winter visitor, but it seems that for the last 15-20 years no birds came to the country.

In April 1958 an isolated colony of the species was found breeding near Ofakim in the Northern Negev. The colony consisted of about 100 nests on akacia bushes beside the road, and extended over about one and a half kilometres. Both the birds and their eggs, 5-7 in number corresponded in size to the Greenfinch, *Chloris chloris*. The nests were lined with cotton, seemingly from the nearby cotton plantations. This colony bred also in the springs of 1959 and 1960 exactly on the same spot. In the winter they seem to disappear from the place. So far this is the only breeding colony found in the country.

2. The Reed Bunting *Emberiza schoeniclus* (L.)

This species was once supposed to be very scarce in this country⁴. In recent years however it appears each winter from November till March. It frequents reed-beds and it is fairly abundant among the fishponds of the Na'aman River. Of the specimens collected, a great percentage was thick-billed, the measurements of the bills varying widely. The thick-billed ones are also bigger and some authors classify them as a group, *Emberiza pyrrhuloides*. Hardy⁵ described one female from Wadi Rubin in the Dr. Moses collection (now in the collection of the Tel Aviv University, No. 1578) as *Emberiza schoeniclus koreyewi* Sarudny. This was adopted also by Bodenheimer.

The thin-billed specimens collected seem to belong to the nominate race, *Emberiza schoeniclus schoeniclus* (L.). Unfortunately many forms of this species have been described, and the exact determination of the races is not a simple task. It seems that the racial determination of the Reed-Buntings appearing in this country requires further investigation.

3. The Penduline Tit, *Remiz pendulinus pendulinus* (L.).

This Tit was also believed to be a rare bird if at all occurring in this country. However, in the winter of 1958–1959 it was a fairly common visitor; several specimens were collected among the fish ponds of the Na'aman. The bird appeared also in the winter of 1959–1960, but in smaller numbers. In 1958–1959 it appeared between November–March. The bird was found chiefly on the reed-stems, looking for food. The only voice heard was a weak, high pitched note.

4. The Bar-tailed Desert Lark, *Ammomanes phoenicura arenicolor* (Sundevall)

This bird described in the past by Ramsey⁷ as from Palestine, had seemingly not been proven by a collected specimen. Its distribution ranges are North Africa, Sinai and Arabia, occurring also in Iraq.

In April 1957 an adult male (now in Hovel collection, No. 618) was collected near Nizanah a few kilometres from the Sinai border. That spring was after a good rainy winter, and bird-life in the Negev was abundant.

One can hope that with suitable conditions, we shall find it again in this area. Another specimen collected in Sinai during the Sinai campaign there in the winter of 1956–1957, is now in the Oranim collection.

5. The collared Turtle Dove, *Streptopelia decaocto decaocto* (Frivaldszki)

Our second resident Turtle Dove (the Palm Dove *Streptopelia senegalensis*) is steadily spreading throughout the country, as in Europe, where it advanced during the last three decades from the south to the north-west. Only several years ago it was known only from the Huleh and Jordan valleys and the Negev. In 1957 the bird was found breeding at Lod. Afterwards it advanced along the shore, and it seems that it shall occupy the whole country and continue its spread towards the north.

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A survey of the parasites of wild mammals and birds in Israel (1956–1960)

O. THEODOR, Department of Parasitology, The Hebrew University of Jerusalem

The purpose of this survey, which was carried out for 4 years on a grant from the National Institutes of Health, U.S.A., was to obtain a coordinated and complete picture of the parasite fauna of Israel of which only small parts have been worked

but so far. Systematic, zoogeographic and epidemiological aspects were studied.

The survey was divided into three sections:

1. Ectoparasites — O. Theodor, M. Costa and H. Leurer.
2. Blood parasites — A. Zuckerman.
3. Helminths — G. Wertheim.

Altogether 1755 mammals (60 species) and 1200 birds (172 species) were examined. 570 of the mammals were rodents.

ECTOPARASITES

Blood sucking Diptera (Culicidae), Phlebotominae, Simuliidae, Ceratopogonidae, Tabanidae and Muscidae) were not included in this survey as they have been worked out previously.

Carnus haemapterus and the blood sucking larvae of *Protocalliphora sordida* were found in the nests of *Passer* and *Petronia*.

Diptera Pupipara. *Hippobosca longipennis* was found on various Carnivores and *Ipoptena chalcomelaena* on *Capra nubiana*. *Pseudolynchia canariensis* was found on a number of birds of various families and several species of *Lynchia* and *Ornithessa metallica* on Corvidae and other Passeriforms.

12 species of Nycteribiidae were found on 15 species of bats, 9 of them on the genera *Myotis* and *Miniopterus*. 4 species of Streblidae were found, among them *Scodipteron rhinopomatos* on two species of *Rhinopoma*.

Siphonaptera. 37 species of fleas were collected of which 18 are new to Israel. Among them are one new subgenus, 5 new species and 9 new subspecies. Only a single species of bird flea, *Ceratophyllus fringillae*, was found in the nest of *Petronia petronia*, and only two species of bat fleas. 28 species of fleas, among them all the new forms, were found on rodents.

Phthiraptera. 24 species of lice were collected, 15 of which are new for Israel and 3 are new species.

Hemiptera. Over 250 species were collected, many of them identified only as to the genus and a number of new species are to be expected among these.

Argasidae. 13 species were collected, 8 of which are new to Israel, among them 4 new species.

Ixodidae. 17 species were collected. 4 species of *Ixodes* are new for Israel. The unknown males of *Ixodes kaiseri* and *Ixodes redikorzevi theodori* were found.

Parasitic mites. About 50 species were collected, most of them new to Israel. This material is being worked out at present by Costa in the British Museum, London.

ZOOGEOGRAPHICAL FINDINGS

A study of the distribution of the above material showed the presence of the following elements in the country:

1. Cosmopolitan
2. Palaearctic
 - a. Widely distributed in various parts of the region.
 - b. Mediterranean
 - c. South Mediterranean or Eremic.
3. Ethiopian
4. Oriental
5. Endemic

A number of parasites showed a narrower distribution than their hosts. *Parapulex chefrenis* occurred south of the line of 100 mm rainfall, while its host *Acomys cahirinus* occurs throughout the country up to the northern frontier.

Ctenophthalmus congener tenuistigmatus n. ssp. does not occur south of Mt. Carr while its host, *Microtus guentheri*, is common in the coastal plain south to Gae

The asiatic origin of *Meriones tristrami* could be confirmed by parasitological evidence. Its specific flea, *Nosopsyllus iranus attenuatus* r. ssp. is the only flea found on *M. tristrami* in the dunes of Acre, where *M. tristrami* is the only Gerbil found. Further south, where other Gerbils of African origin occur, *M. tristrami* acquires from them their characteristic parasite, *Synosternus cleopatrae*.

EPIDEMIOLOGICAL FINDINGS

Ixodidae. Larvae and nymphs of various species of *Hyalomma* were found on 31 of the rodents examined, on hares and on birds in the Dead Sea area. This is of particular interest in connection with the epidemiology of Theileriasis.

Relapsing fever. Several strains of spirochaetes were found in the blood of Gerbils but their identity with *Spirochaeta persica* has not been demonstrated so far. *Peromyscus* have not been found infected with spirochaetes. *Meles meles* is the only animal so far found infected with *Sp. persica*.

Plague and Endemic Typhus. *Xenopsylla cheopis*, the vector of both these diseases is present in the coastal plain as parasite of the population of domestic rats throughout the year, but most prevalent in summer. It was found on only 1.6% of the rodents examined, mainly on *Acomys*. The wild population of *R. rattus* seems to have no connection with the population of domestic rats in the coastal plain which entered the country through the ports, bringing *Xenopsylla cheopis* with it. The wild population of rats is thus unlikely to serve as a reservoir of plague.

No indication of the presence of rural plague among wild rodents was found. This is of interest, as *Meriones tristrami* in Kurdistan was the reservoir of an outbreak of plague in 1957 and *Nosopsyllus iranus attenuatus* n. ssp. is closely related to the vector of the outbreak of plague in Kurdistan.

BLOOD PARASITES

Several species of *Plasmodium*, *Haemoproteus*, *Leucocytozoon* and *Atoxoplasma* were found in birds. Species of *Nuttallia*, *Bartonella*, *Aegyptianella* and *Trypanosoma* were also found. The life cycle of *Trypanosoma acomys* was worked out.

HELMINTHS

Over 200 species of Cestodes, Trematodes and Nematodes have been collected. This material is being worked out and no results can be given at present.

Some differences in the running pattern in two spider families Uloboridae and Argiopidae

A. SZLEP, *Section of Invertebrate Morphology and Animal Physiology, Department of Zoology, The Hebrew University of Jerusalem*

The web of the Uloboridae as that of the Argiopidae is an orb-web. In spite of the similarity in the main web structure there are differences in the running pattern of the spiders.

In Uloborus the running pattern is similar to that of radii placing. The spider runs along the radius taking a drag-line with it. At the return the drag line thread is replaced by another and the previous thread is swallowed. As the web is placed in the horizontal plane the spider is suspended during running time beneath the web and the fine structure of the web is not damaged at all.

In Argiopidae, on the other hand, the spider neither replaces the drag-line, nor swallows it. As their webs are placed in the vertical plane, the spider is running along a radius and is not suspended beneath the web. This running pattern effects the interconnections of the spiral rows and causes a damage in the fine web structure.

A quantitative study of venom secretion by *Vipera palaestinae*

A. KOCHVA, *Department of Zoology, Tel-Aviv University*

Observations on the secretion of venom by 150 captive *Vipera palaestinae* indicate that snakes separately caged and properly cared for may be milked regularly for 3 years or longer, and large quantities of venom can thus be obtained. With artificial heating, the milking can be continued throughout the year.

No influence of ecdysis, pregnancy, or food consumption on the yield of venom was observed.

Taking into account the amounts and concentration of the venom obtained as well as the physical well-being of the snakes, a period of rest of one month between milkings is suggested. Temperature was found to be one of the factors governing the venom yield. A rise in temperature increased both the amount and concentration of venom. The freshly secreted venom is rather dilute initially and is subsequently concentrated by the reabsorption of water.

The amount of venom injected in a single bite was estimated by allowing the vipers to strike dead mice. The amount injected was found to range from nil to 190 mg of fresh venom; in most bites less than 50 mg (mean 32 ± 3.1) were injected.

The mean proportionate amount injected was approximately 11% of the venom available in the glands, in most strikes less than 15% of the available venom was injected.

Results obtained in the laboratory when considered in relation to the severity of viper bites in human beings, suggest that the minimal lethal dose of *Vipera palaestinae* venom for man is approximately 75 mg.

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The fauna of the hot springs of Israel

D. KAHAN, *Section of Invertebrate Morphology and Animal Physiology, Department of Zoology, The Hebrew University of Jerusalem*

In the course of the present survey of the living organisms of the hot springs of Israel, bacteria¹, algae, amoebae, flagellates, ciliates (50°C-60°C), round worms (48°C) and Diptera maggots (39°C-40°C) were found in Tiberias hot springs, at the Zohar hot springs (30°C) and at the sulphur springs near Ein Gedi (39°C). A number of species of protozoa were found among the other animals, algae, bacteria, even though the sulphur springs are submerged beneath the waters of the Dead Sea for a few months each year. Of these springs only those of Tiberias were previously investigated but no living organisms were found².

Various species of protozoa have been isolated from the fauna of the Tiberias hot springs and are at the present being cultured at a temperature of 50°C. The aim is to develop axenic cultures for investigation of the mechanisms that enable these organisms to endure such high temperatures.

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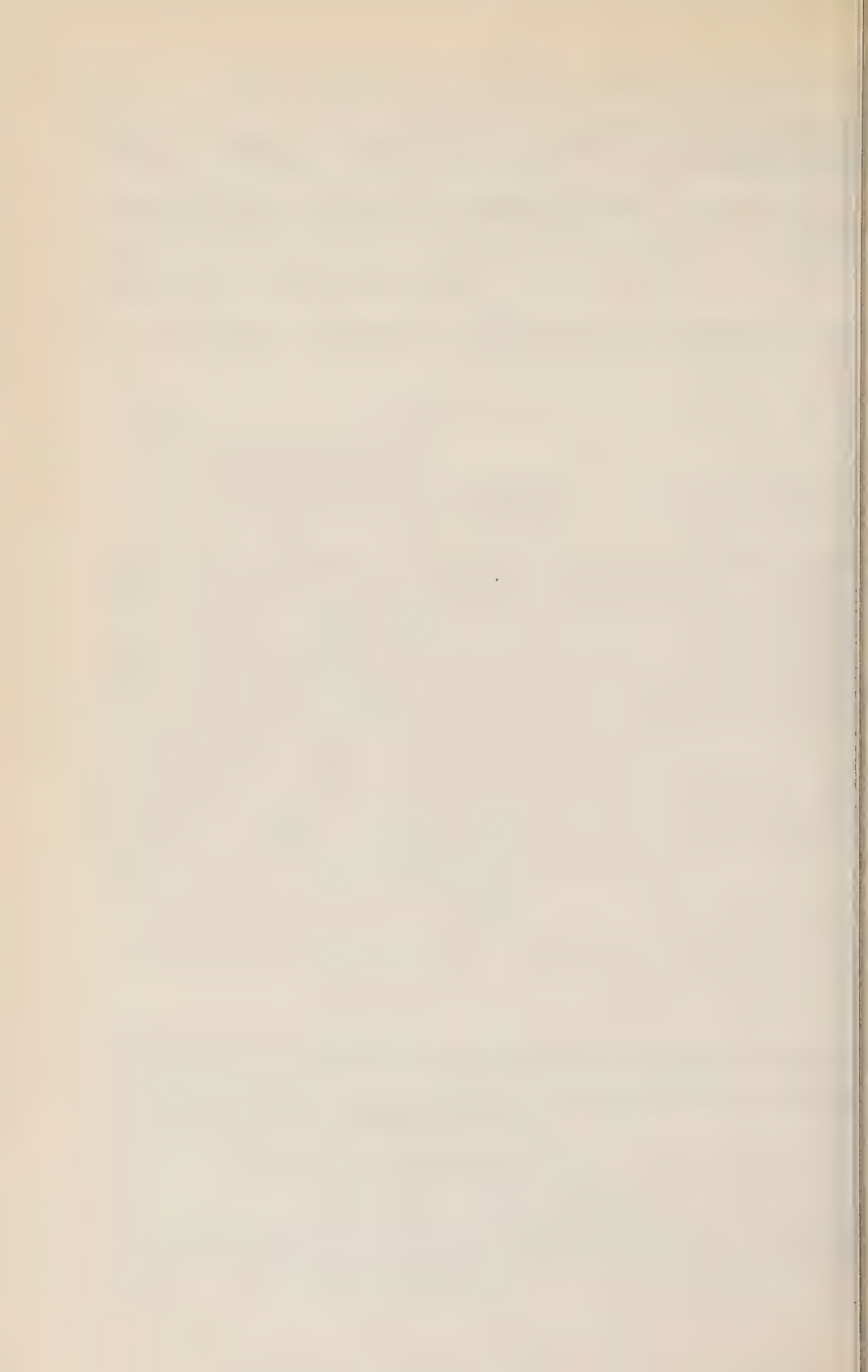
A study on the source of celluloses in the digestive tract of *Levantina hierosolyma* Bo

I. PARNASS, *Section of Invertebrate Morphology and Animal Physiology, Department of Zoology, The Hebrew University of Jerusalem*

Experiments performed upon snails whose digestive tract was cleansed of bacteria by treatment with antibiotics, prove an auto-production of cellulases in the hepatopancreas. Cellulolytic activity which is found in other portions of the alimentary canal in untreated snails may be attributed to bacterial activity or to the penetration of these enzymes from the hepatopancreas.

Experiments on the possibilities of arrested development in the eggs of *Schistocerca gregaria* Forskaal

M. P. PENER AND A. SHULOV, *Department of Zoology, The Hebrew University of Jerusalem*



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יוצא לאור ע"י

מוסד ויצמן לפרסומים במדעי הטבע ובטכנולוגיה בישראל
המועצה המדעית לישראל - משרד החנוך והתרבות - האוניברסיטה העברית בירושלים
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